

NIF Update

JLF and NIF User Group Meeting

Mark Herrmann
NIF Director
Thanks to the NIF team

February 1, 2016



LLNL-PRES-682077

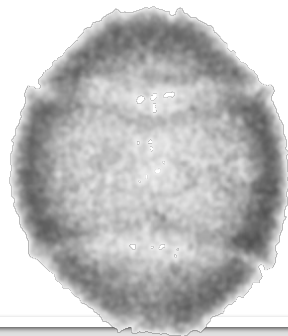
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

 Lawrence Livermore
National Laboratory

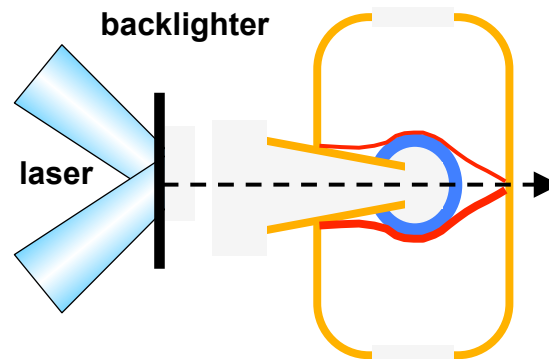
It's an exciting time in the field of High Energy Density Science and on the National Ignition Facility

- NIF has had a very successful year:
 - High impact programmatic results
 - Significant increase in scientific productivity
 - Development of important new experimental capabilities
- The Discovery Science program has had a successful year as well.
 - Completed the first round of proposals with 44 experiments in FY15. Each team was successful in obtaining useful data
 - The second round teams are beginning their experiments now
 - The third round of proposers has been awarded time for FY17/18
- New capabilities are continually being developed for NIF, which will expand its capabilities for performing new science
- Discussion topics

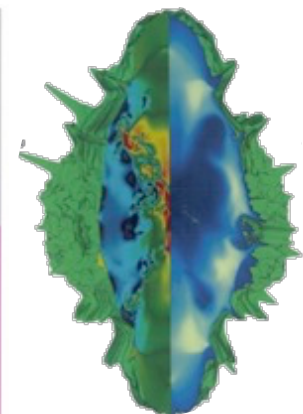
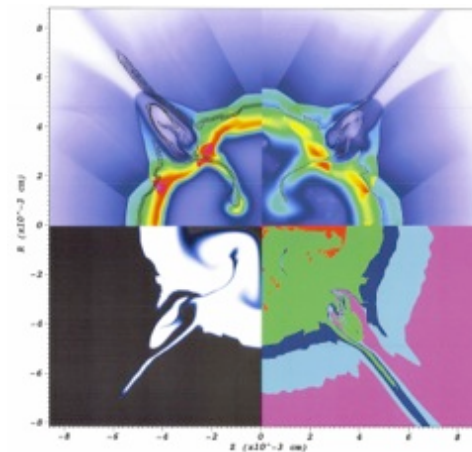
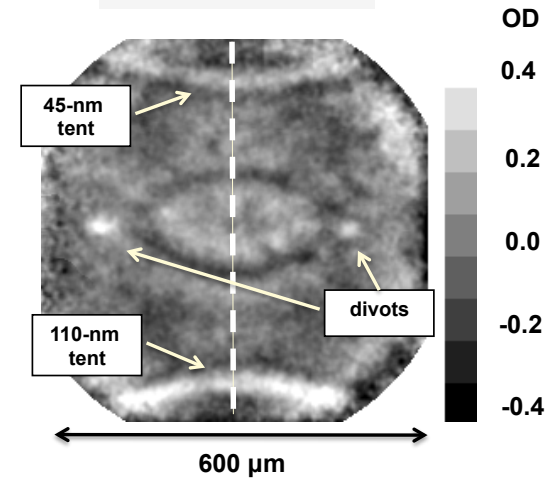
New experimental data together with 2D and 3D simulations highlighted the importance of finding other ways of holding the capsule



Experiment setup

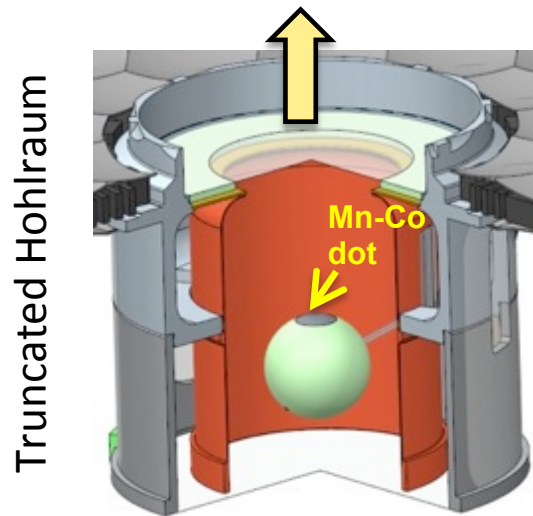


Radiograph

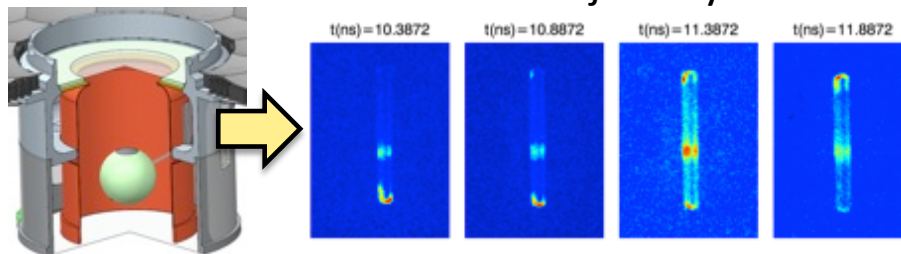


By selectively placing dopants on the surface of a capsule the plasma motion and conditions in the interior of the hohlraum has been probed

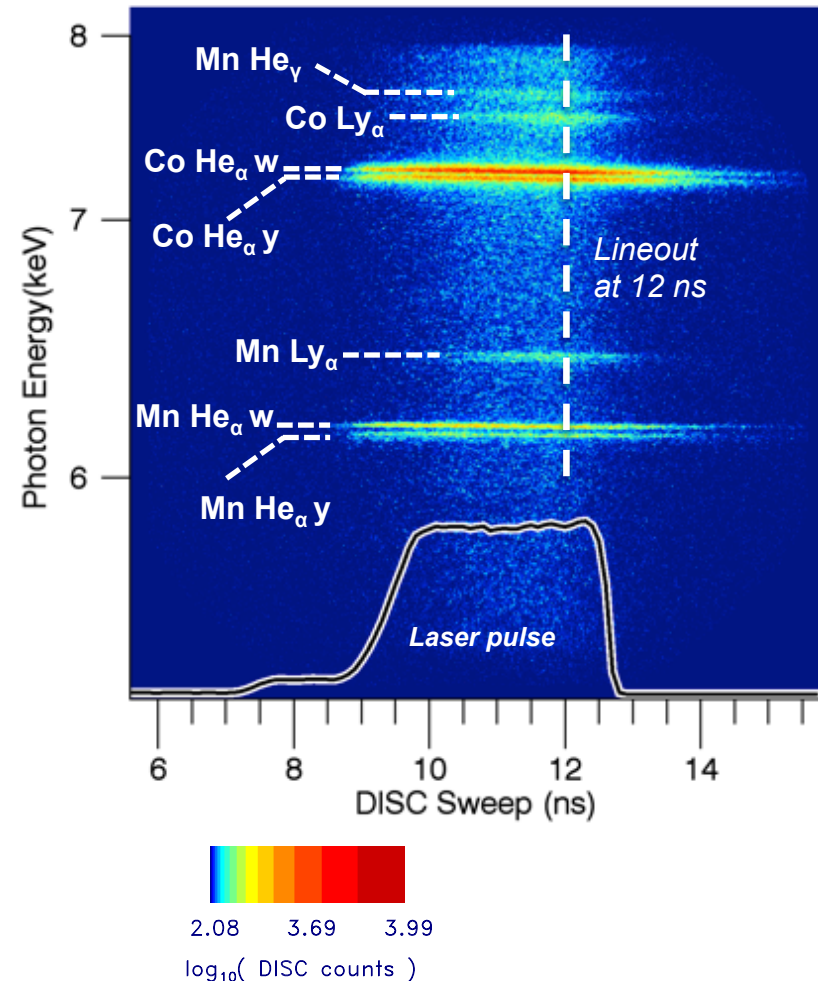
Time resolved X-ray spectrometer (plasma Te)



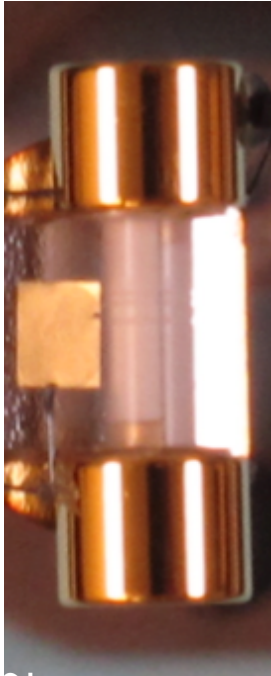
Dot Trajectory



Spectral streak



Los Alamos performed 17 shots on NIF in FY15 to understand mixing in the presence of shear



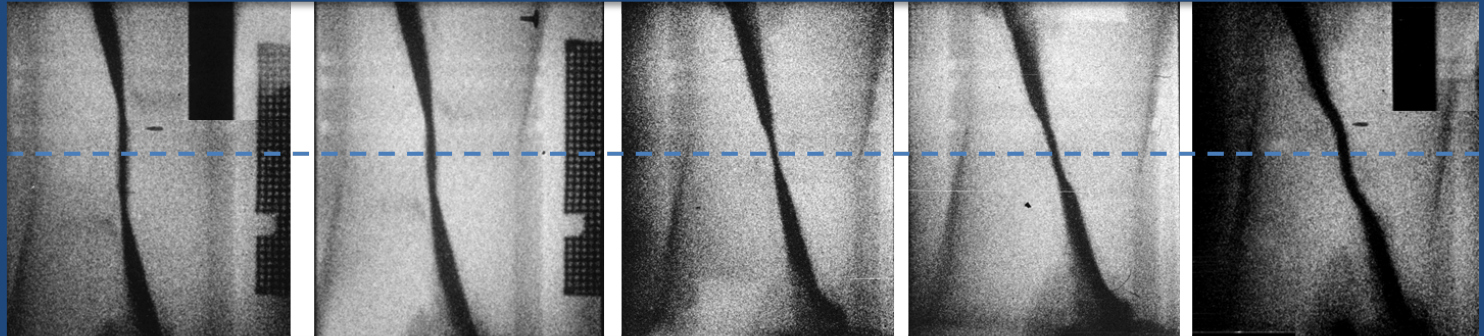
16.4 ns, S01-1

18.6 ns, S01-2

19.4 ns, S05-1

20.8 ns, S05-2

21.8 ns, S03-1



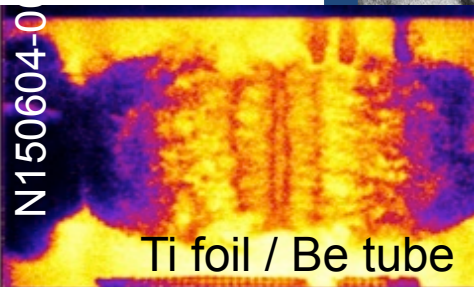
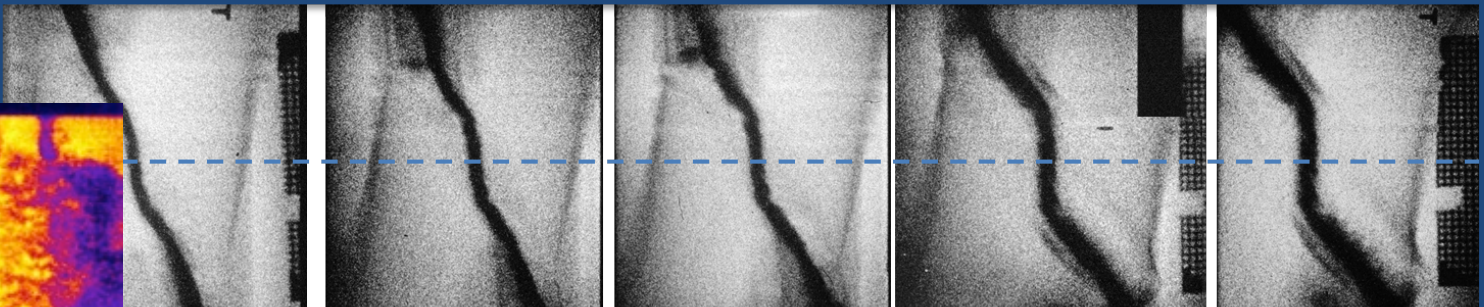
23.0 ns, S03-2

24.4 ns, S06-1

25.6 ns, S06-2

27.2 ns, S02-1

28.4 ns, S02-2

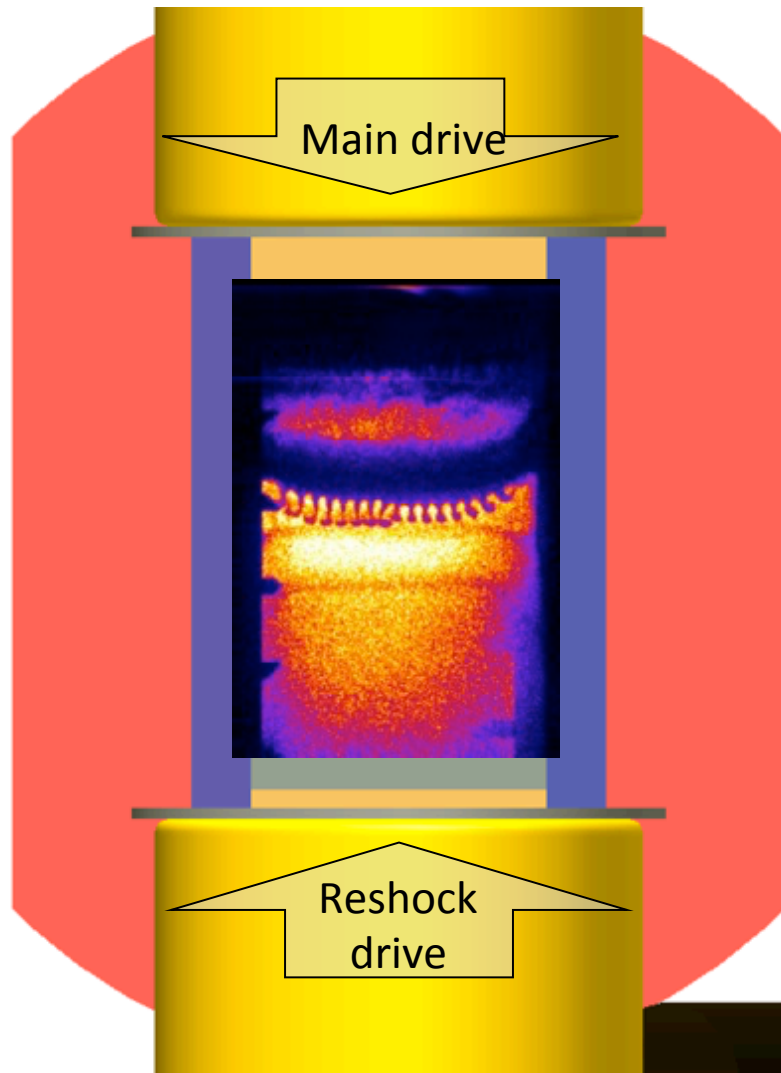


Ti foil / Be tube

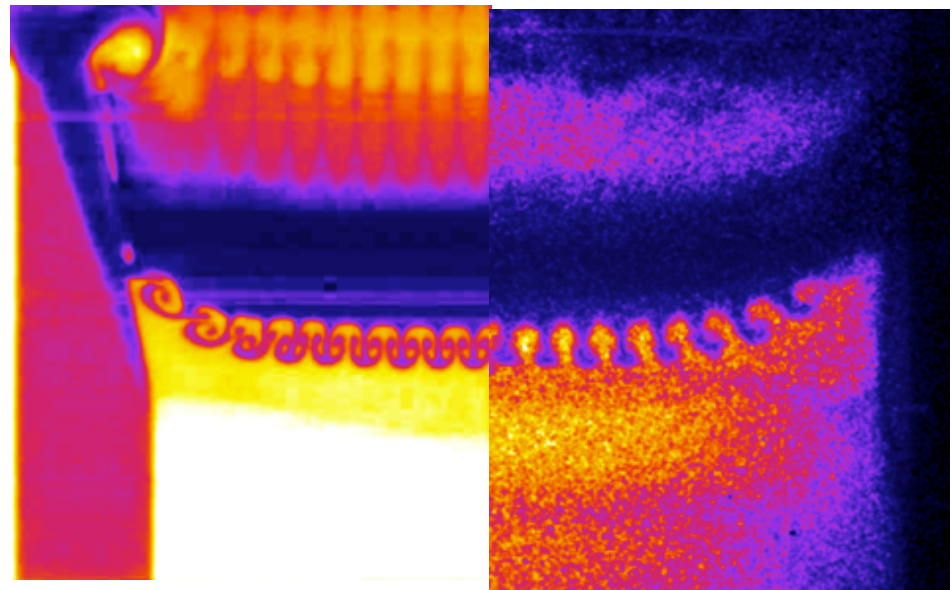
F. Doss, J. L. Kline, K. A. Flippo, et al. *Phys. Plasma* **22**, 056303 (2015)

This work relies heavily on NIF's precision and shot to shot reproducibility

A collaboration between LANL and LLNL is obtaining beautiful data on instability growth during reshock for comparison with simulations



NIF's large energy enables large features to be driven and radiographed enabling detailed comparisons with simulation

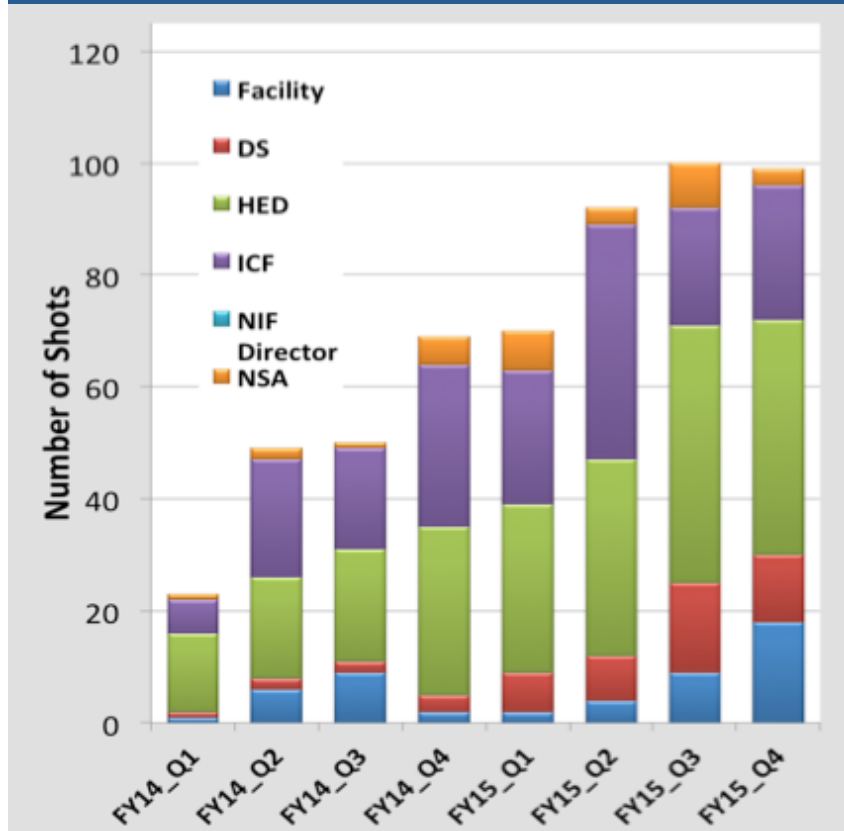


Simulation

Experiment

We are significantly increasing the scientific productivity of the NIF

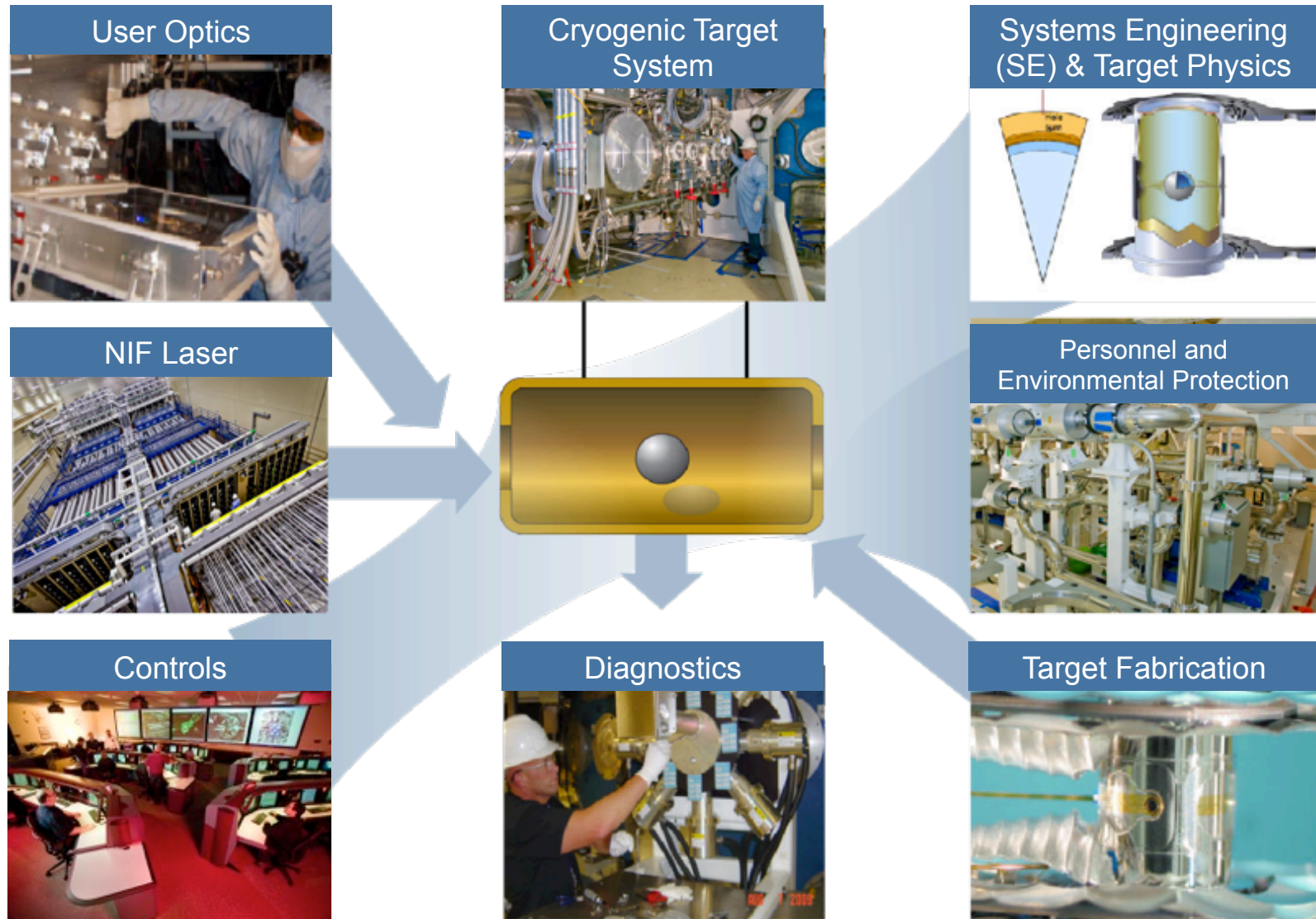
Target shots by quarter and shot rate



- We increased the number of experiments from 191 in FY14 to 356 in FY15 with fixed funding
- More experiments enable a faster rate of learning, more exploration, and more users on the facility
- User satisfaction has remained high (>90%) as the number of shots has increased
- We have brought several new diagnostics on line and deployed new experimental capabilities enabling new measurements
- Number of publications per year with NIF data is rapidly increasing

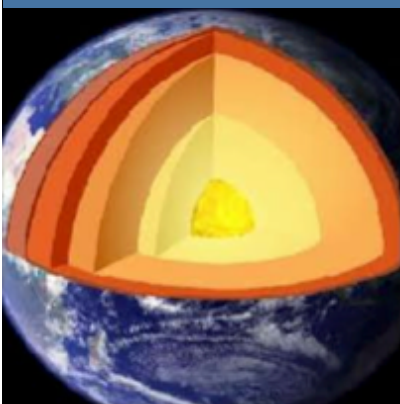
This trend will continue in FY16. Current schedule has >400 experiments.

Shot rate improvements have been made in all laser and experimental systems – and will continue



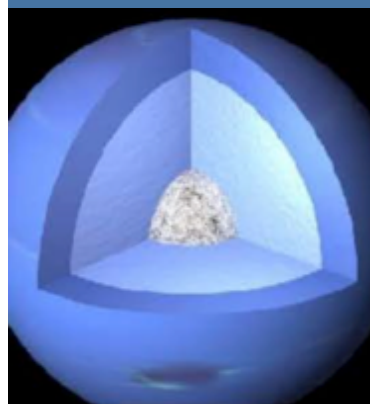
NIF allocates a small fraction (~8%) of the facility's time to "Discovery Science". 8 teams completed the initial allocation in FY15.

C, Fe EOS at planetary interior pressures



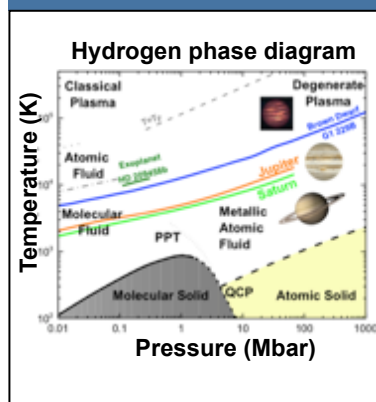
Duffy (Princeton), Jeanloz (UCB)

High pressure phases of carbon



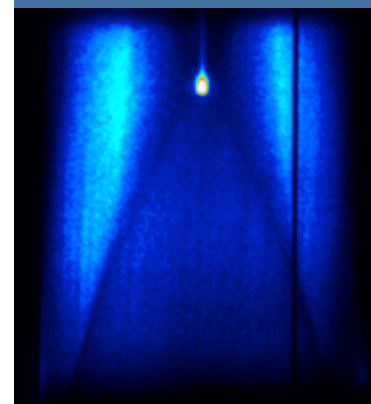
Wark (Oxford)

High pressure hydrogen properties



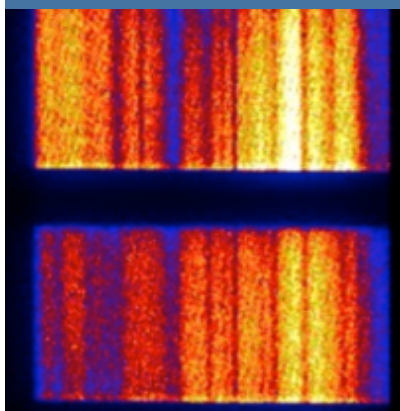
Jeanloz (UCB), Hemley (CIW)

CH and carbon at near Gbar pressures



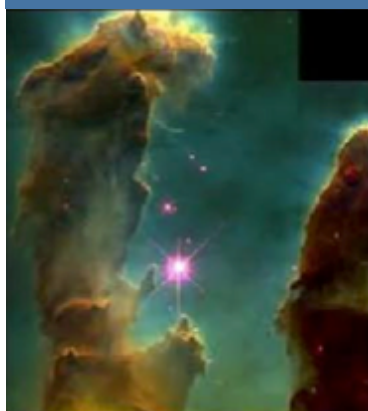
Falcone (UCB), Neumayer (GSI)

Planar ablation front
Rayleigh-Taylor growth



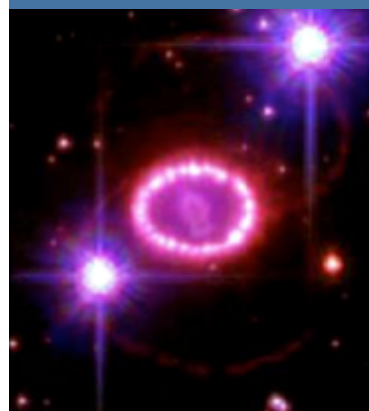
Casner (CEA)

Molecular cloud
radiative dynamics



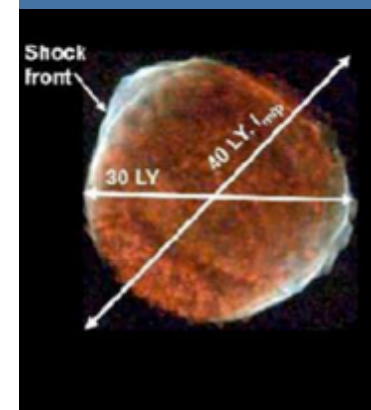
Kane (LLNL), Pound (Maryland)

Supernova explosion
rad. hydrodynamics



Kuranz, Drake (Mich)

Collisionless
astrophysical shocks

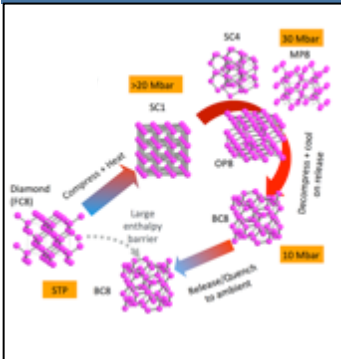


Sakawa (Osaka), Takabe (HZDR)

**Discovery Science had 44 target shots in FY15 versus
26 DS shots total in FY10-FY14**

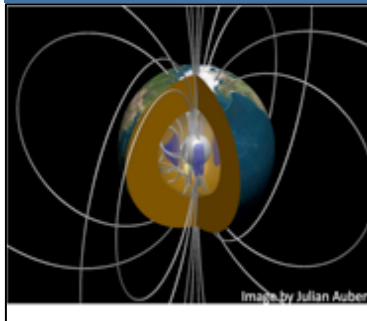
We began nine new NIF-DS experiments in FY16; first shots were in Dec.

Metastability of dynamically compressed C



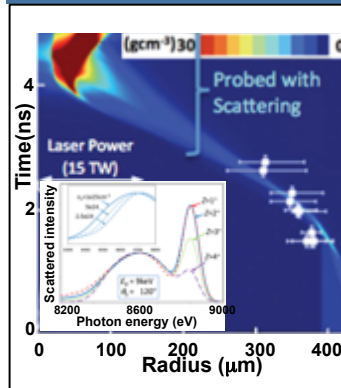
Wark (Oxford)

Iron melt curve, magnetospheres, and habitable Super Earths



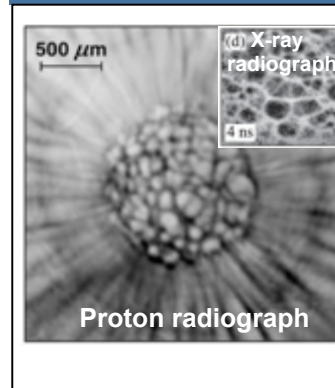
Hemley (CIW), Stewart (UCD)

Pressure ionization at extreme densities



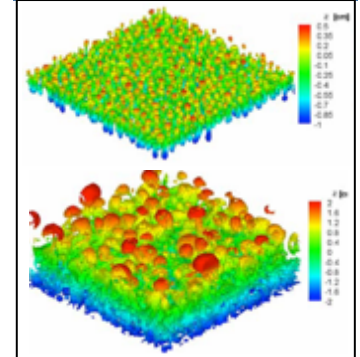
Neumayer (GSI), Falcone (UCB)

Direct-drive hydrodynamics



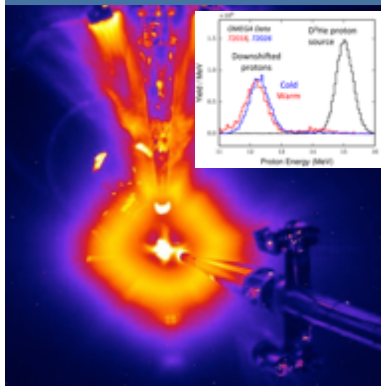
Casner (CEA),

Asymptotic self-similar instabilities



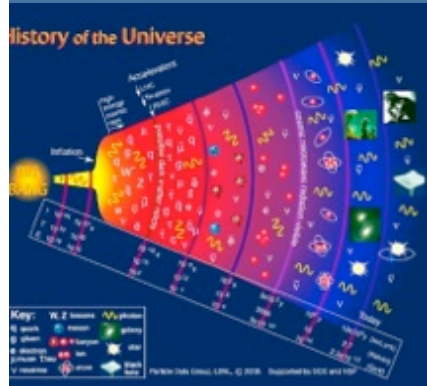
Shvarts (Israel), Drake (Mich)

Charged particle stopping powers



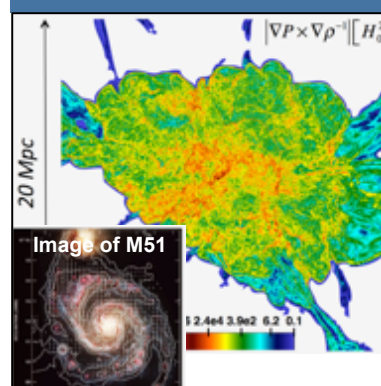
Zylstra (LANL), C.K.Li (MIT)

Stellar and Big Bang nucleosynthesis



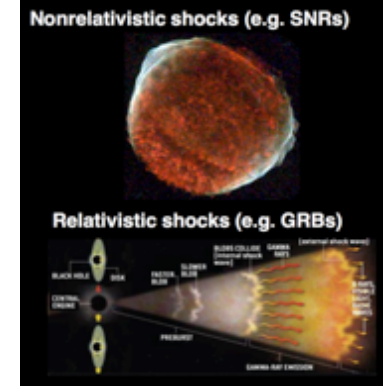
Gatu-Johnson (MIT)

Turbulent dynamo B field amplification



Gregori (Oxford), Lamb (Chicago)

Collisionless astrophysical shocks

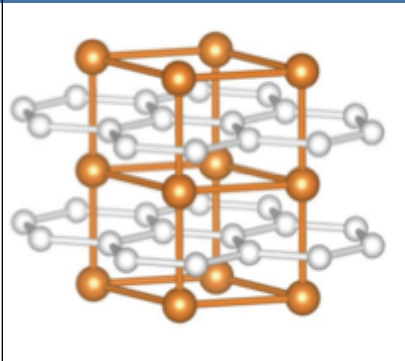


Sakawa (Osaka), Spitkovsky (Princeton)

22 high quality DS proposals were received for the FY17-18 DS round; 8 were selected by the Discovery Science Technical Review Committee.

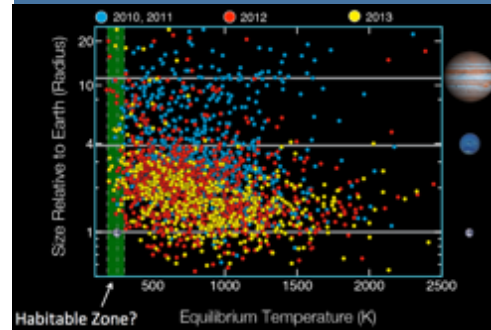
McMahon U. Edinburgh:
Mg electrides

Mg at extreme
densities



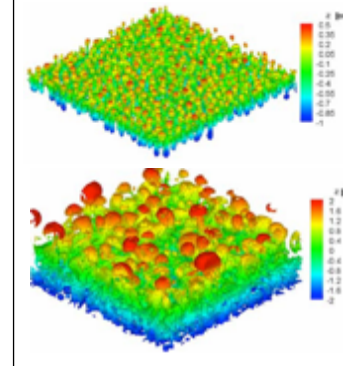
Hemley, CIW:
TarDIS_FeMelt

Iron melt curve, magnetospheres,
and habitable exoplanets



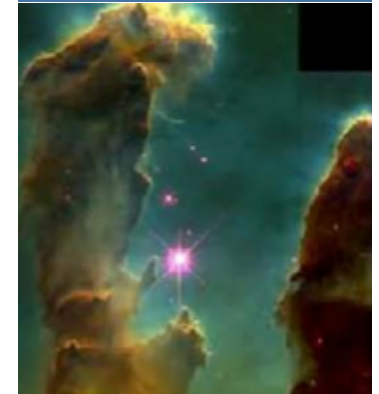
Shvarts, NRNC/U. Michigan:
nonlinear hydro

Asymptotic
self-similar
instabilities

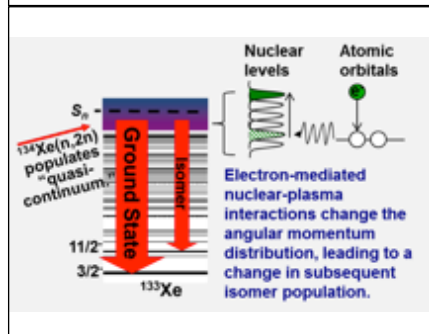


Pound, U Maryland:
Eagle Nebula

Molecular cloud
radiative dynamics



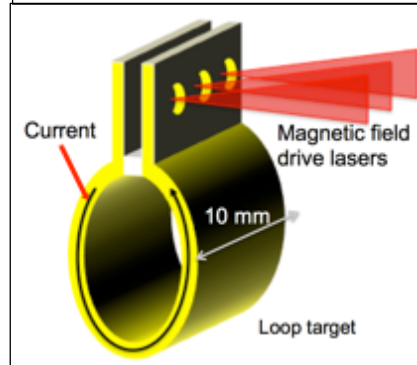
Berzak-Hopkins, LLNL:
nuclear reactions in plasma



Fox, Princeton:
Magnetic reconnection



Pollock, LLNL: laser-driven
B field generation



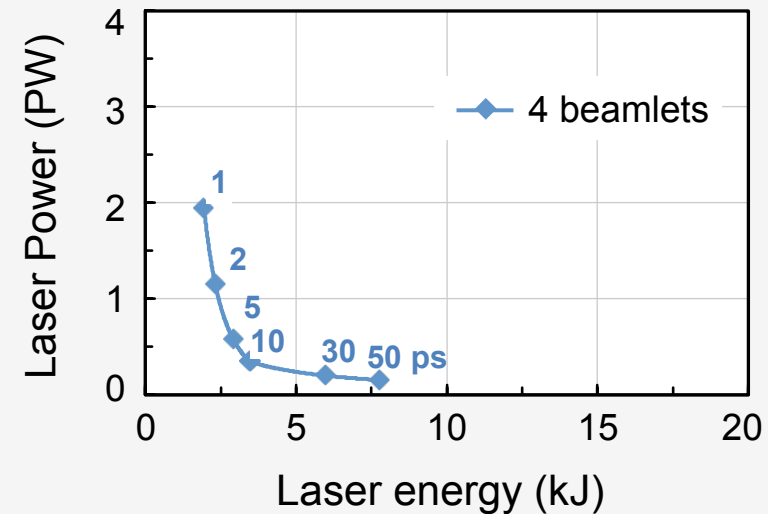
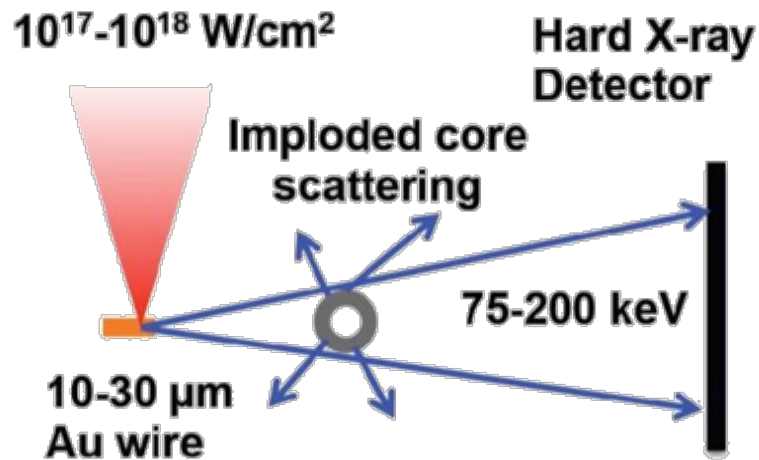
Chen, LLNL: hot e^- ,
 e^+ in ARC driven samples

Rel. e^-e^+ plasmas present
only in astro. events



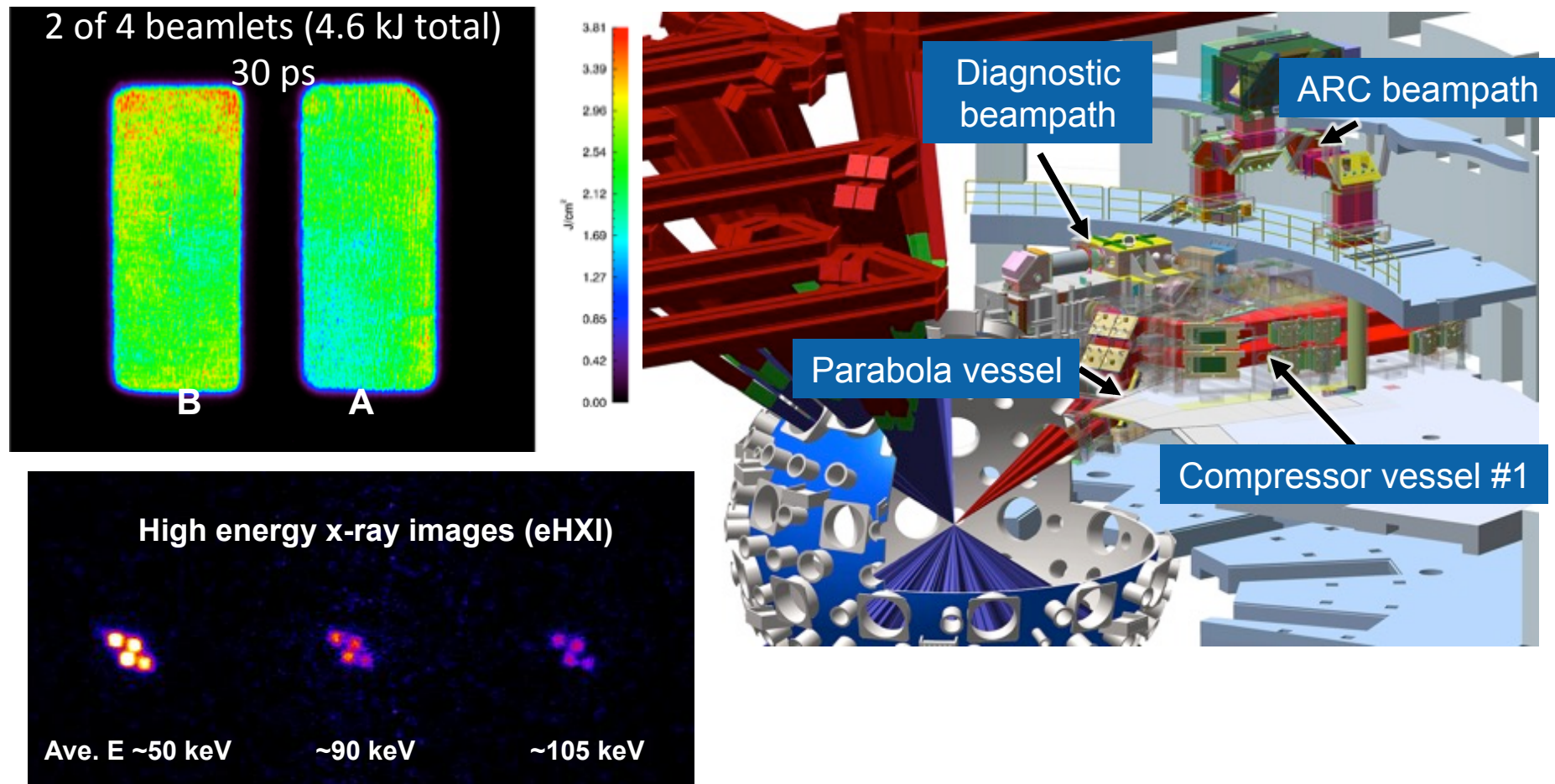
NASA/CXC/CIA/R. Kraft et al.

The Advanced Radiographic Capability adds a short pulse laser to NIF and will enable new scientific measurement



Description	Ignition Need	HED Need	Initial Performance
Peak irradiance/sub-aperture beam (half NIF beam)	$\geq 10^{17} \text{ W/cm}^2$	$\geq 10^{17} \text{ W/cm}^2$	$\geq 10^{17} \text{ W/cm}^2$ @ 30 ps
Pulse energy/sub-aperture beam (half NIF beam)	400 J... 1.5 kJ	$\geq 1 \text{ kJ}$	400 – 1200 J
Pulse width (adjustability)	1 ps... 30 ps	$\leq 100 \text{ ps}$	1 – 30 ps

The Advanced Radiographic Capability (ARC) has been commissioned and the first backlighter development shots took place in December



The next step for ARC is to deliver on high profile programmatic milestones in FY16. We will hold a workshop to explore uses of ARC beyond backlighting.

**ATLAS
(2016)**

ATLAS is a high speed laser tracker alignment system for the diagnostics and the target alignment sensor

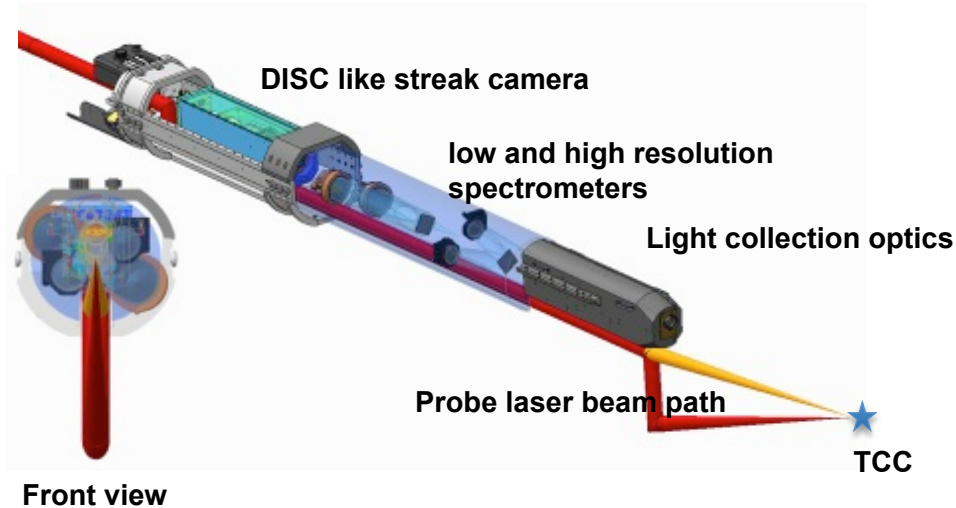
**TANDM (1st
in 2016)**

TANDM is the next generation dual warm target and diagnostic positioner enabling fast exchanges

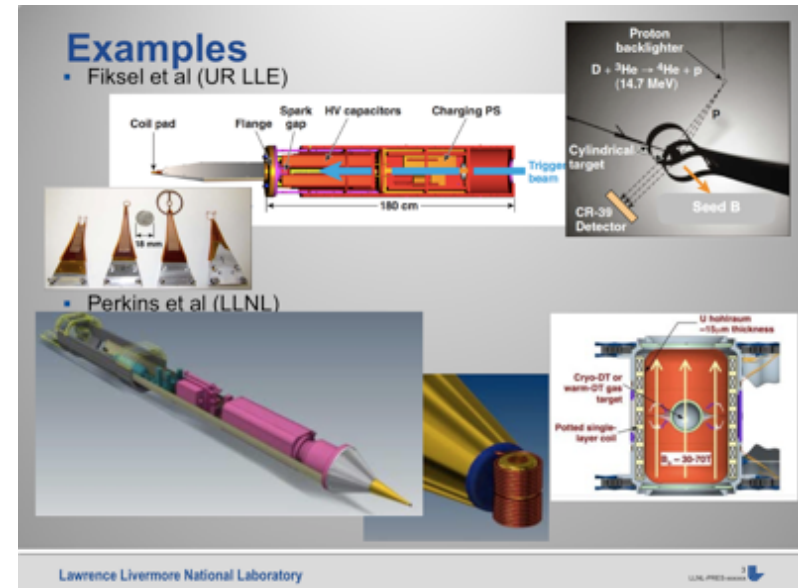
On Demand Simp Rep 90-348 AREA

We continue to develop new diagnostics and new experimental capabilities for NIF

Optical Thomson Scattering



Magnetic Field Capability



National Diagnostics Initiative to develop transformational diagnostics(multiple meetings 2015)

Bfield Workshop October 2015

Rate of development depends on complexity, funding, and programmatic priorities

Challenges remain going forward

- There is a fierce competition for resources within NNSA as there is far more work to be done than money available and many stakeholders (NNSA, DOE, DOD, Congress)
- At least some in Congress/Administration are still advocating for full cost recovery for academic experiments on NIF
- Funding opportunities for successful PI's are very limited, this is a long term concern for growing a vibrant user base.
- Our funding model constrains our Discovery Science Program
 - NNSA does not allocate any additional money or set aside money for our DS Program
 - We can support DS activities that meet NNSA's partnership model: Shot time, targets, limited new/modified diagnostics, liaison scientist time
 - Proposals that require major investment or significant development are severely constrained by the current funding model
- Out year budgets (FY17-) are very uncertain due to the national political climate

We can partially address these challenges by performing and publishing stunning science and broadly communicating the work

It's an exciting time in the field of High Energy Density Science and on the National Ignition Facility

- NIF has had a very successful year:
- The Discovery Science program has had a successful year as well.
- New capabilities are continually being developed for NIF, which will expand its capabilities for performing new science
- Discussion topics
 - We continue to learn and make improvements to the annual call process
 - Process itself, LOI, proposal, oral presentation
 - Balance of experimental time per proposal
 - New experimental capabilities and the DS program

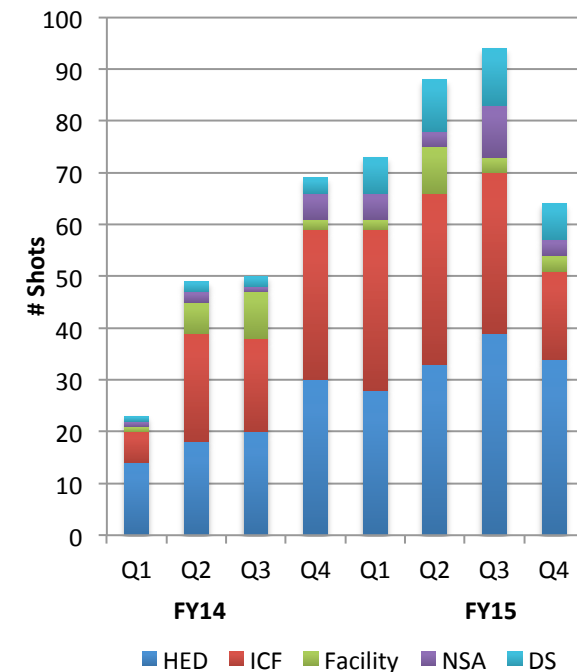
Questions?





There are opportunities for increasing partnerships on our HED facilities

- In many ways, Z and NIF are like some Office of Science high-energy physics facilities:
 - Single end-station
 - Heroic efforts to execute experiments
 - Multimillion dollar diagnostics with ~100 contributors
- However, we have a unique challenge not constraining for most Office of Science facilities – *an applied mission!*
- We have a vibrant existing program in non-laboratory funded work in HED science
 - SSAA, SSGF, NLUF, various summer schools
- We are increasing partnerships with nuclear threat science communities and we are pursuing an agreement with OFES
- We are interested in supporting a partnership vice ownership model
 - Do our interests align?
- Deployment of "ownership" user-models are commensurate with our other priorities. We recognize a need to:
 - Develop target design-constrained catalog of arbitrary sources
 - Improve access to facilities (efficient operations)
 - Establish an NLUF-like program to fund non-laboratory PIs
- The “120-Day Study” forms the backbone of our shot-rate improvement effort
 - Includes ~ 80 specific actions
 - About half completed in FY14
 - Remainder planned for FY15 and FY16



The key to enabling partnerships is increased operational efficiency at NIF and pursuit of dedicated materials science platforms

Discovery Science Technical Review met in October 2015 to rank proposal for time in FY17

Dr. Riccardo Betti	University of Rochester
Dr. Richard Firestone	LBL
Prof. Nathaniel Fisch	Princeton University
Dr. Siegfried Glenzer	Stanford University
Dr. Denise Hinkel	LLNL
Prof. Karl Krushelnick	University of Michigan
Dr. Ramon Leeper	LANL
Dr. Mordy Rosen	LLNL
Dr. John Sarrao (Chair)	LANL
Prof. Sarah Stewart	U.C. Davis
Prof. Ellen Zweibel	University of Wisconsin



- 34 Abstracts were received in July 2015.
- 22 full proposals were reviewed in October by the DS TRC committee
- 8 proposals were accepted for a total of 18 shot days.

We have a call for proposals for new capabilities for the facility

- **NIF's funding includes a dedicated funding line for Diagnostics, Cryogenics, and Experimental Support for developing new capabilities needed to support both current and future users.**
- **MTE 10.3 funding request is \$44.1M in FY16**
- **We apply this funding to four areas to make NIF more capable for users**
 - Diagnostics, Transformative capability, Broad, Local
 - Facility Infrastructure
 - New Laser Capabilities
 - Cryogenic Target Capabilities
- **To enhance the transparency of how these funds are allocated in FY15 we**
 - Issued a call for new capabilities proposals to the entire community
 - Estimated costs for all items requested
 - Circulated list to program leaders and asked for prioritization. Formal input from the national HED Council, ICF Council, National Diagnostics Team and the Facility
 - Used that input to develop a prioritized list, incorporating what is needed for long term stewardship of the Facility
 - Discuss with NNSA HQ and then notified the community

An extensive list of new capabilities was requested (80+ items, estimated costs > \$160M)

Optical Thomson scattering	OTS	5w Optical Thomson scattering	1/1/17	FY15	FY17	John D. Moody	mood y4@llnl.gov	LLNL	Measure Temperature of hohlraums, radiation flow experiments	Diagnostics	ICF	9259	FY16: deploy detector on shot to collect background; complete laser design and long-lead procurements; des/install laser mount and laser enclosure. FY17: install laser and transport system; integrate with detector to commission OTS
1st Multifunction positioner - intended as 3rd Target inserter	TANDM1	New target positioner capable of inserting room-temp targets; based on common DIM/Target multifunction design	8/1/16	FY15	FY16	Doug Larson	larson8@llnl.gov (925) 422-1524	LLNL	Allows interleaved target experiments on two target inserters while dedicating CryoTarpos to layering	Infrastructure	Facility	8800	Design, fab, offline test and deploy new capability
Single line of sight detector	SLOS	Support to development of SLOS prototype (10 ps 3D x-ray imaging)	9/1/16	FY16	FY16	D. Bradley	Admin can fill out	LLNL	Increase data return on single shots	Diagnostics	ICF	3902	Fund GA and assemble & deploy finished product with KB3
ATLAS	ATLAS	Improved alignment for polar DIM	FY17	FY15	FY16	Doug Larson	larson8@llnl.gov (925) 422-1524	LLNL	Improved alignment enables Neutron imaging & x-ray imaging in polar DIM	Infrastructure	Facility	2485	Deploy ATLAS for DIMS and TAS including reflectors on snouts
Near-polar DIXI	DIXI2	Add a second Dilation Imager for X-rays at Ignition (DIXI) detector at the North Pole to provide a nearly orthogonal X-ray line of sight to the existing DIXI.	9/30/17	FY16	FY17	Perry Bell	bell11@llnl.gov	LLNL	Provides a orthogonal X-ray line of sight to the existing DIXI. Better time resolution from the pole	Diagnostics	ICF	2047	Repackage existing DIXI design to work on the pole
Beam based PSS and blocker capability	PSS/Beam	Provide 4x increase in blockers per beamline	TBD	FY16	FY18	Suratwala		LLNL	Provides increased power/energy or lower cost operation relative to quad-based PSS	Laser	Facility	1500	

We implemented a new, national process for determining the priorities for new capability investments on NIF

Category		FY15 Plan (\$M)	FY16 Est (\$M)
Diagnostics		23.9	30.0
	Transformational	6.4	14.4
	Broad*	10.8	5.1
	Local	6.7	10.7
Cryogenics		1.3	1.3
Infrastructure		9.7	7.9
Laser		12.1	4.8
Total		47.1	44.1

Table 1: Distribution of LLNL MTE 10.3 funding in FY15 and FY16

MTE 10.3 FY16 plan (\$k)	Total
Cryo	1300
Faster layering	600
Tritium on TARPOS	700
Diagnostics	30040
Broad	5060
ARC X-ray Imager	600
Hardened x-ray readout to eliminate film	1980
In-situ Neutron Activation Detectors	650
Increased streak camera resolution (DISC)	850
Precision nTOF	980
Local	10700
Assemble/fab HGXD 4/5	950
KB2 and KB3	2250
Minor diagnostic upgrades	2500
Opacity Spectrometer	150
polar nToF	2020
Rotating frame for GXD or DISC	450
Spherical Crystal Imager / Backlighter	580
Survey Spectrometer	1300
TARDIS well upgrades	500
Transformational	14380
Magnetic Recoil Spectrometer for time-resolved measurements of neutron spectrum	450
Optical Thomson scattering	3750
Polar neutron Imaging	2600
Single line of sight detector	3400
SLOS LEH-t	350
Spectrometer for Kr ne	1350
Time-Resolved Reaction History	1150
Wolter	650
X-ray optic calibration & alignment	680
Infrastructure	7900
1st Multifunction positioner - intended as 3rd Target inserter	4500
Applied B-field using pulsed power	300
ATLAS	1900
Evaluate configuring NIF for symmetric direct drive	1200
Laser	4760
Beam based PSS and blocker capability	1060
Blue Blockers	400
Low cost GDS finishing	350
PDD path forward - Phase 0	850
Performance quad setup	1150
PSS beam shaping for high-power pulses (by quad)	600
Stud pulses - amplitude modulation at high-frequency	350
Grand Total	44100

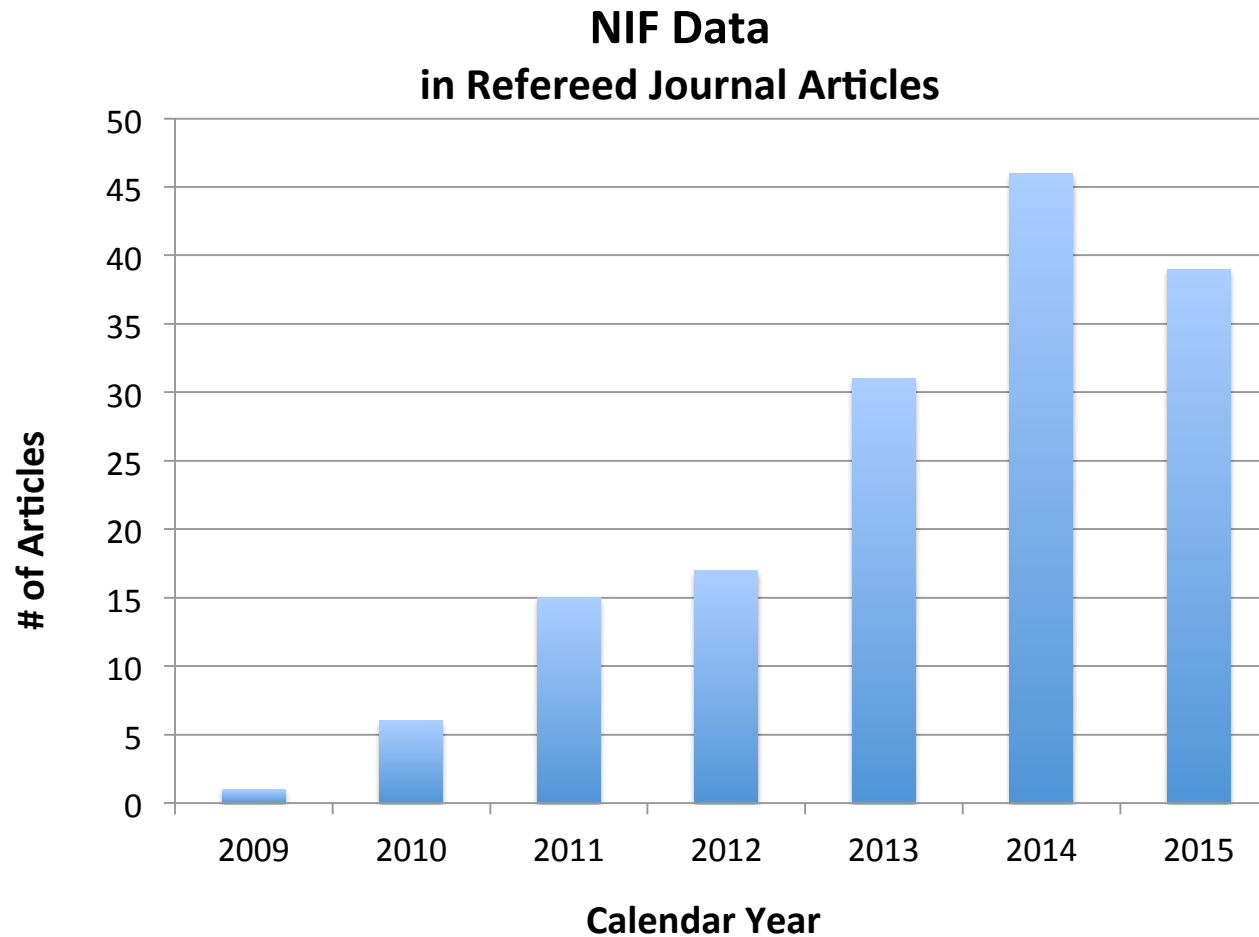
Table 2: Detailed summary of FY16 plan

Our annual allocation of days for experiments is distributed across multiple programs

- NIF runs 24/7
 - 2 days per week are dedicated to maintenance
 - 5 days for shot operations
- Facility Maintenance and Reconfiguration
 - 1 week 3 times per year
 - 3 weeks once per year
- Facility time is allocated for
 - Diagnostic calibration
 - Diagnostic or new capability Qualification
- Director's reserve is allocated for
 - Contingency for programmatic shots
 - Development of new capabilities

Program - Shot Days	Annual Alloc.
Non-ignition SSP	80
Ignition SSP	80
National Security Applications	14
Discovery Science	18
Facility	17
Dir Res	17
Total	226

The number of publications with data from NIF is growing



Going forward our strategy is to continue to enhance NIF's capabilities to support SSP and help advance all of the programs

- **Develop next generation transformational diagnostics**
- **Enhance the power and energy at which experiments can be routinely performed**
- **Expand the suite of target materials, geometries and configurations**
- **Continue to increase shot capacity and scheduling agility to better support the Programs**
- **Create more opportunities for innovation and enhance the vitality of HED experimental science**
- **Explore potential options for major new capabilities on the NIF**

Achieving these goals requires a world-class, engaged workforce